EUV Source Optics with 100% OOB Exclusion

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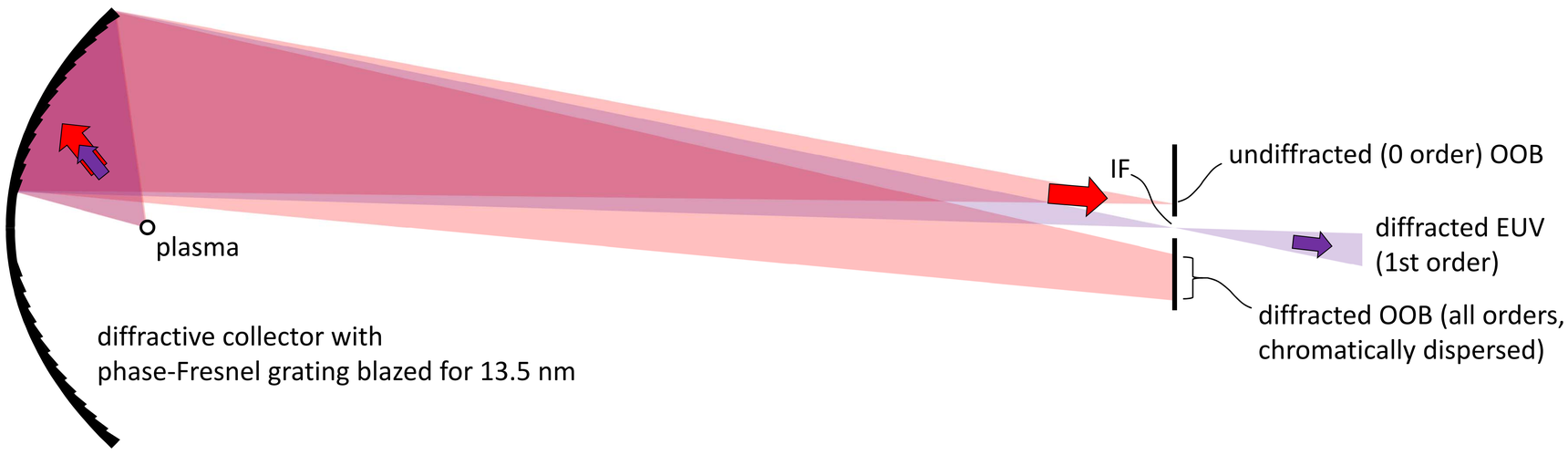
Zero-OOB Collector

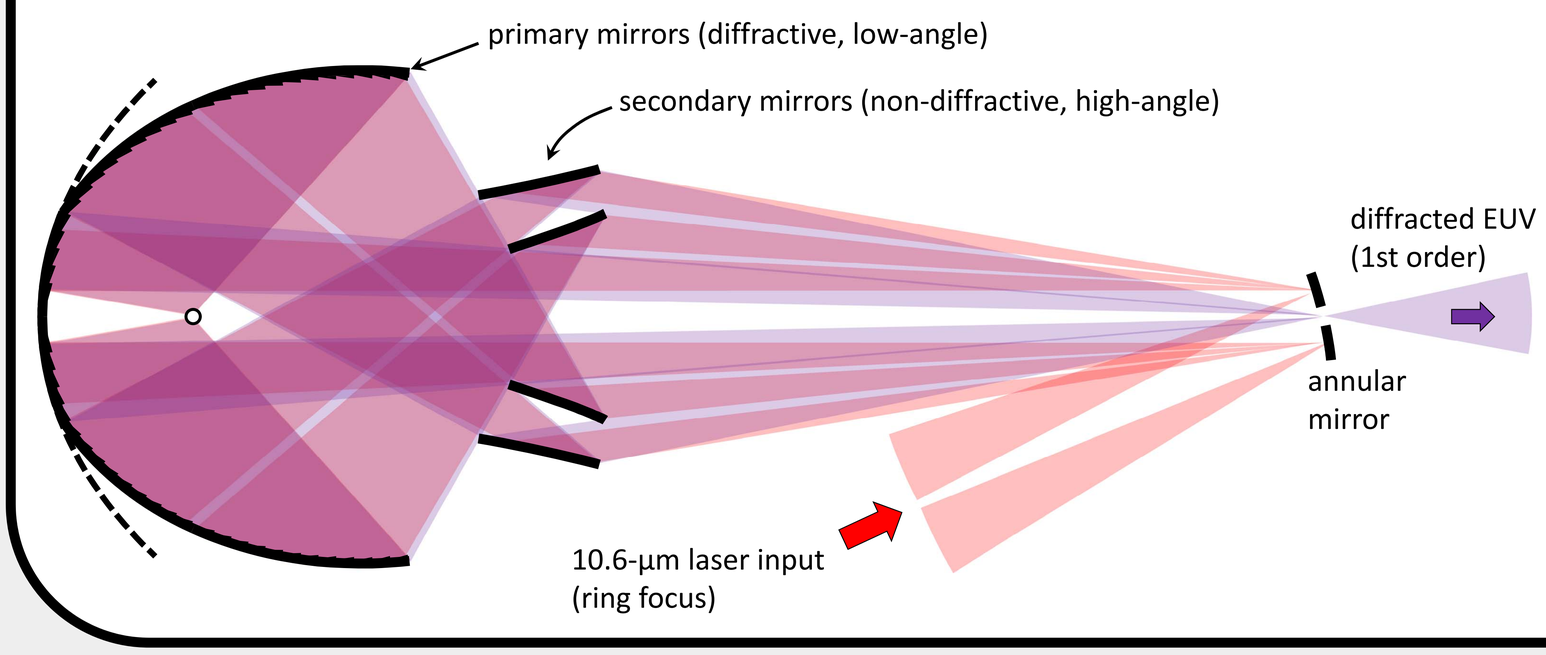
A phase-Fresnel grating can separate long-wave radiation out of the EUV light path for OOB exclusion, effectively operating the collector as a grating monochromator:



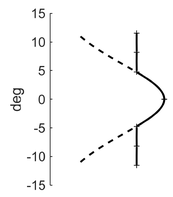
illustrative design configuration:
- plasma-to-IF distance: 1.5 meter
- mirror-to-plasma: 199 mm
- mirror diameter: 633 mm
- collection angle at plasma: 81.5°
- collection angle at IF: 11.6° (NA = 0.2)
- maximum incidence angle: 35.0°
- plasma clearance diameter: 500 µm
- 0-to-1st-order separation angle: 2.6 mrad
- minimum grating period: 5.2 µm
- IF aperture diameter: 4.4 mm

Dual-Function 10-sr Collector

The grating can also merge zero-order laser light ***into*** the EUV light path for wide-angle plasma irradiation:



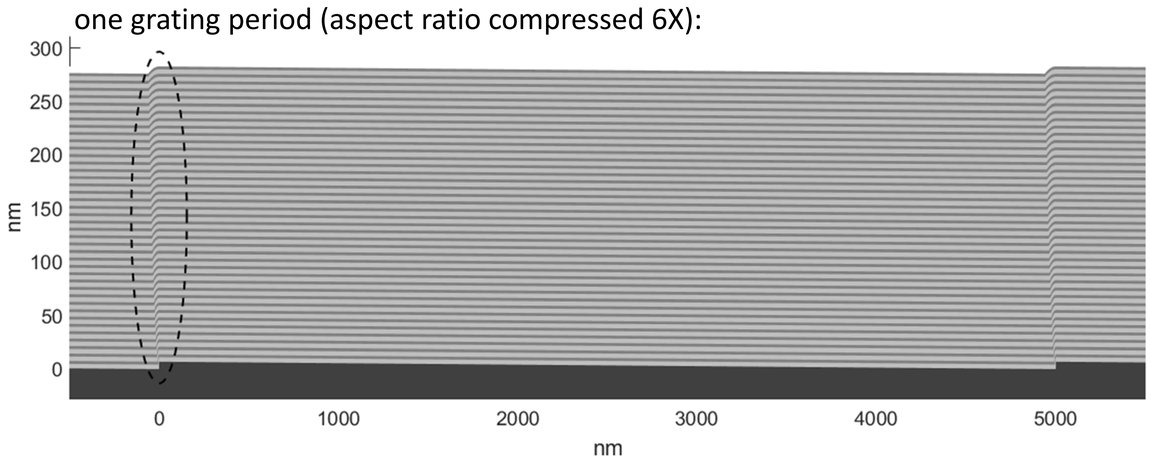
output angular intensity profile (incl. mirror refl.)



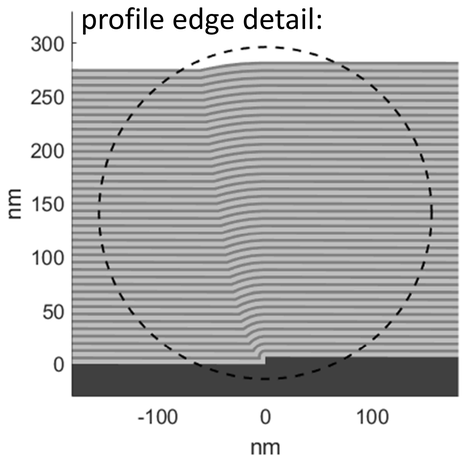
illustrative design configuration:
- plasma-to-IF distance: 1.5 meter
- mirror-to-plasma: 199 mm
- mirror diameter: 658 mm
- collection angle at plasma: 131.6° (>10 sr)
- collection angle at IF: 11.6° (NA = 0.2)
- incidence angles
  - on primary, maximum: 35.5°
  - on secondary, minimum: 55.6 °
- plasma clearance diameter: 500 µm
- 0-to-1st-order separation angle: 1.2-4.7 mrad
- minimum grating period: 2.8 µm
- IF aperture diameter: 12.0 mm
- IF annular mirror outer diameter: 38.7 mm

Conformal-Multilayer Grating Structure

one grating period (aspect ratio compressed 6X):

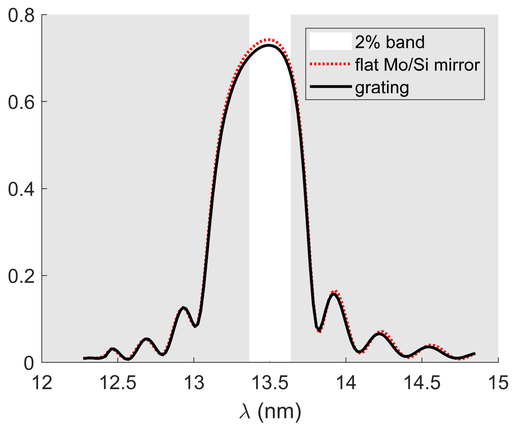


profile edge detail:



Illustrative design configuration:
- normal incidence
- grating period: 5 µm
- 40 bilayers, 4.19 nm Si \ 2.71 nm Mo
  (276-nm stack depth)
- substrate pattern depth: 6.9 nm
- Mo/Si layers distorted by edge discontinuity
  (conformal deposition)

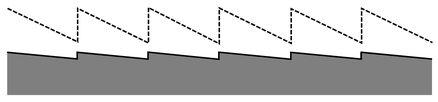
Efficiency Simulation



RCWA simulation:
- orders included: -100…+101
- depth stratification: 0.2 nm
- Mo/Si layers (no capping/barrier layers)
- Layer edge distortion included in model.

Grating's relative efficiency
(vs flat Mo/Si mirror): **98%**

Grating Manufacture



Process:
(1) Form a precision-machined, super-polished substrate base surface (either in Ni or a secondary substrate layer deposited on Ni).
(2) Deposit a machinable, sacrificial layer on the substrate.
(3) Cut a grating pattern in the sacrificial layer with a single-crystal diamond edge. The grating is much deeper than the target dimension (e.g. ≈100 nm).
(4) Blanket-etch the structure to transfer the pattern into the substrate. The substrate etches much slower than the sacrificial layer, resulting in a shallow (7-10 nm), high-fidelity grating pattern.